Characterization of Magnetizing Process for Pre-Embossed Servo Pattern of Plastic Hard Disks

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Abstract – Rigid disks which have pre-embossed servo patterns have been developed. These media make it possible to follow tracks less than 5μm pitch. The substrates are made from plastic; and pre-embossed servo patterns and discrete data tracks are made by a stamping technology similar to optical disks. To generate signals from pre-embossed servo patterns, the magnetization direction of the elevated pattern and recessed area must be opposing. Therefore, a two-step magnetization method has been developed. Based on experimental results, optimum conditions are met when the magnetization transition occurs at the upper edge of the patterns.

I. INTRODUCTION

Discrete track media(DTM) for magnetic disks have been proposed to increase track density[1],[2]. However, they have been produced by means of etching of magnetic layer, which is not appropriate for mass-production.

Therefore we have developed a new method to make DTM. In this method pre-embossed patterns are made on plastic substrate by an injection molding process similar to optical disks.

We call these disks PERM(Pre-Embossed Rigid Magnetic)Disk. The benefits of PERM disk are as follows:

(1)Servo patterns can be permanently embossed on the disk surface with a high degree of accuracy.
(2)Substrate with low production cost can be made from plastic using injection molding technology.
(3)High quality magnetic thin films can be realized even on plastic substrates[3].

To generate signals from servo patterns on PERM disk, a 2-step magnetization process is required. In this paper, a characteristics of this process are described.

II. STRUCTURE OF PERM DISK

The substrate is 65mm in diameter and 1.2mm thick. The embossed substrate is textured with a fine dispersion of SiO_2 particles by dipping[4]. The under layer (Cr), magnetic layer(CoCrPt), and protection layer(C) are directly sputtered over the entire surface. A lubricant layer is then applied over the protection layer by dipping.

Pattern height is 200nm and minimum pattern length is 1.2μm.

A patterning scheme is shown in Fig.1, and pattern dimensions are in TABLE I. Sample servo method is used to position magnetic head[5]. This method requires more sample points than conventional sector servo method, but the frequency range of position signal is to be expanded because of high sampling rate. In our experiments the number of servo zones is 420, and they are placed in arc which trace the range of motion of the magnetic head.

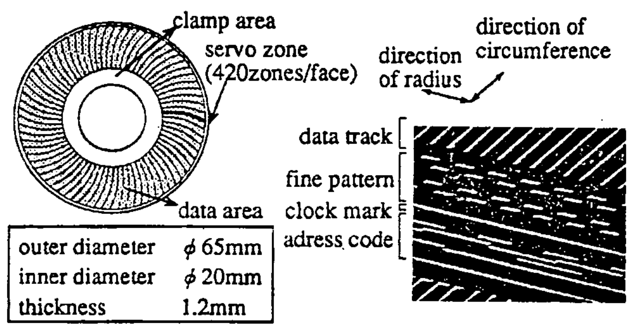

Fig.1 Patterning Scheme

TABLE I
PATTERN DIMENSIONS

Track Pitch	4.8μm
Track Width	3.2μm
Guard Band Width	1.6μm
Number of Servo Zones	420
Number of Unique Patterns	69
Number of Home Index Pattern	1

Clock marks are used to generate precise servo clock and data clock for sampled servo system. Unique patterns are used to identify clockmarks initially. Home index pattern is used to decide phase origin of each surface. Address code and fine pattern are used to generate position signal.

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III. MAGNETIZATION

A. Principle

To generate signals from pre-embossed patterns with magnetic head, magnetic transitions are required. To make magnetic transitions the magnetization direction of the elevated pattern and recessed area must be opposing. Therefore a 2-step magnetization method has been developed[6].

The first step is a full DC erase of medium; the second step erases only elevated patterns with magnetization direction opposite to that of first step. With this method, magnetic transition occurs between elevated patterns and recessed area as shown in Fig.2.

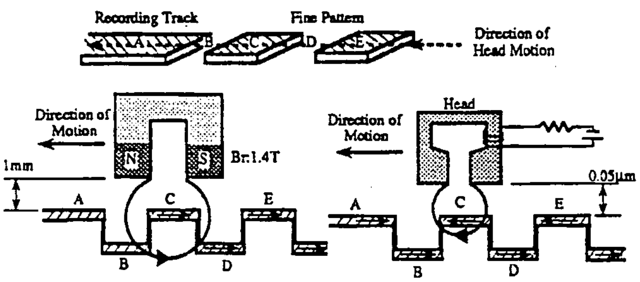

Fig.2 2-Step Magnetization Method

B. Experiment

A strong magnetic field is required to magnetize the recessed area sufficiently in the first step. Therefore, in our experiment, a neodymium alloy permanent magnet whose Br is 1.4T was used. The spacing between this magnet and the media is 1mm. At this point, field strength is 940kA/m.

The coercivity of a medium is 120kA/m. Therefore field strength of the magnet is sufficiently strong to magnetize the entire surface.

For the second step to magnetize only elevated patterns, a field distribution must be sharp and field strength must be adjustable; in our experiments, a magnetic head on nano slider is used. Head dimensions are shown in TABLE II.

TABLE II
HEAD DIMENSIONS

Read Track Width	3μm
MR-Shield Gap	0.25μm
Write Track Width	3.5μm
Write Gap length	0.4μm
Flying Height	0.05μm(On DTM,velocity=9.4m/s)

C. Results

To detect home index patterns, unique patterns and address code, the time interval of read back pulses must be equal to electrically designed value. In our experiment amplitude and pulse interval between leading and trailing pulse of a clock mark pattern was measured. Amplitude is defined as Vc and time interval is defined as Ti as shown in Fig.3. Amplitude(Vc) and time interval(Ti) of clock mark are measured as a function of magnetizing current(Iw_2). Iw_2 dependency of Vc and Ti are shown in Fig.4.

As Iw_2 increases, Vc increases until it reaches maximum point. After passing the maximum point, Vc begins to decrease with increasing Iw_2.

Near the maximum point, deviation of Vc is small, and Td is relatively constant. The point at the end of this range is the maximum amplitude point.

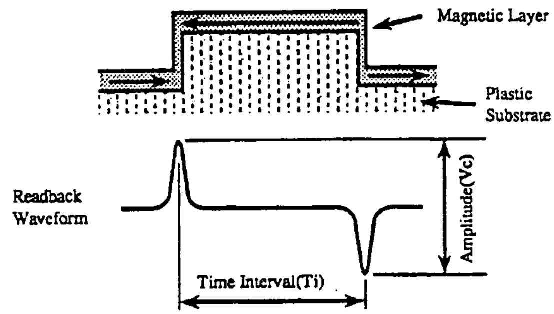

Fig.3 Measurement of Pulse Interval

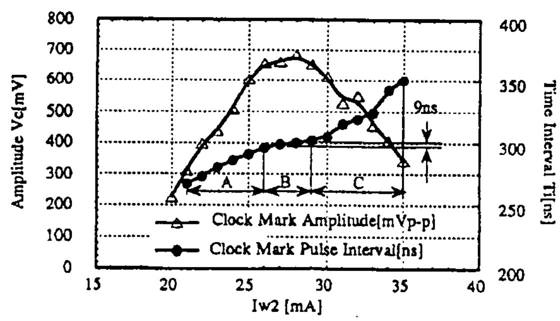

Fig.4 Iw_2 Dependency of Amplitude and Duty

IV. DISCUSSIONS

The physical characteristics of embossed patterns are shown in Fig.5. This pattern edge angle is measured to be 50 degrees by AFM.

The experimental results are explained as follows:

A. Increasing Segment (Segment A)

In this segment, Ti and Vc are increasing rapidly. To measure Ti pattern shape is shown. The rapid increase of Ti can be explained by the fact that the patterns' upper of surface have slightly bowed shape. As Iw_2

increases, the transition location rushes towards the edge of the upper surface; Ti is, therefore, relatively sensitive to changes in Iw_2 when the magnetization transition occurs on the horizontal "planes".

B.Optimum Segment (Segment B)

In this segment Vc is maximized and Ti is relatively constant as a result of the steep slope of the pattern edge. The deviation of Ti is 9ns which is 3% of designed value, and is very small. Therefore only amplitude(Vc) can be maximized. This segment is below the upper corner edge of the patterns.

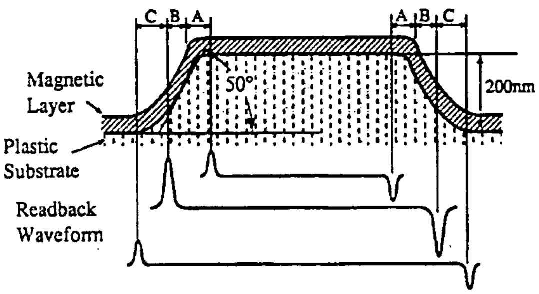

Fig.5 Physical Characteristics of Embossed Patterns

C.Decreasing Segment(Segment C)

In this segment Ti increases relatively quickly while Vc decreases.

The position of magnetic transition moves down along a gentle slope, so Ti increases rapidly.

Also the spacing between head and magnetic transitions increases. In addition to the above, as Iw_2 increases, the recessed area is demagnetized by opposite magnetize field[7].

Reproduced waveform under optimum condition is shown in Fig.6. Position signal generated from this reproduced signal made it possible to follow a track whose pitch is $4.8\mu m$.

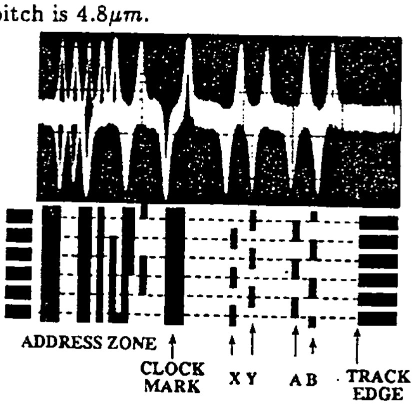

Fig.6 Reproduced Waveform with Optimum Condition

V.CONCLUSIONS

To generate signals from pre-embossed media, 2-step magnetization method is required. It is shown that amplitude and pulse interval of read back signals are optimized when magnetic transitions occur below the upper corner edge of the pattern. The characteristics of 2-step magnetization method are as follows:

(1)A wide optimum range of secondary magnetization current are obtained.
(2)Under the optimum condition, the deviation of pulse interval is 3% of designed value.

Reproduced signals under the optimum condition made it possible to follow a track whose pitch is $4.8\mu m$.

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